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A Gardening Lesson From the Natural World: How Forest Ecosystems Can Provide For Us

Megan Gladbach
mgladbach12@gmail.com

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Abstract
Though agriculture of the past lead to the rise of civilization, degenerative agricultural practices today may very well lead to the demise of civilization. Fortunately, nature offers a solution. By studying and manipulating the inner workings of ecological systems for the gardeners' benefit, resilient gardens, specifically forest gardens, can be created. This paper explores processes that occur in the natural world such as the hydrologic and nitrogen cycles, biotic interactions, and succession and how to mimic them. Concluding with a real-world example, this paper demonstrates that gardens can thrive with minimal input while still providing an abundant variety of food, fuel, and other important resources.

Cover Page Footnote
Professor Steve Giambrone was the Faculty Advisor for this Honors contract.

Introduction

The garden has proved itself to be a revolutionary part of human history. With agriculture, humans were able to transition from nomadic hunter-gatherer lifestyles to stationary ones. Rather than spend their time foraging for food, humans could spend their time developing new technologies. As humans continued to evolve, their gardens followed suit. Agricultural practices today have improved by leaps and bounds from the first cultivated crops; they are extremely productive and, thus, able to provide food for millions of people. Unfortunately, many of these practices have become particularly unsustainable in that they meet the needs of the present but compromise the needs of the future.

The custom of tilling or plowing, loosening soil by digging, stirring, and overturning, demonstrates the previous statement accurately. While tilling can contribute to a bountiful harvest by releasing nutrients and helping to suppress weeds, aerating the soil in this manner negatively affects future generations. To explain, "the life in tilled soil releases far more nutrients than the plants can use" (Hemenway 82). These unused nutrients then wash away and must be replaced in the now depleted soil the following season by tilling again or applying fertilizers. Both of these methods once more provide crops with more food than they can metabolize and generate runoff filled with an overabundance of nutrients. This runoff pollutes lakes and streams leading to accelerated eutrophication, a process that "results in the excess growth of algae and plants [and] diminished lake clarity, light penetration, and oxygen concentrations which can have impacts on aquatic life" ("Lake Succession and Eutrophication"). In essence, though tilling the soil provides an abundant supply of food for people today, this practice depletes the soil and diminishes the water quality of future generations inhibiting their ability to provide for themselves.

These illustrated issues call for the need to evolve the garden once more. A different perspective considers forces of nature as advantages rather than disadvantages. For example, rather than fertilizing and suppressing weeds by tilling, this new outlook incorporates “weeds” to fertilize. To illustrate, clover, known to many as a noxious lawn weed, actually forms symbiotic relationships (“an ecological relationship in which two species live in close contact with each other”) with bacteria that convert atmospheric nitrogen into a form of nitrogen plants can use (Reece et al. 570). Moreover, instead of viewing the fact that organisms must eat other organisms as a burden, this approach thinks of it as a convenience and applies integrated pest management to encourage predators to eat troublesome pests as an alternative to toxic pesticides. This new perspective is ecological gardening, growing and cultivating plants by using natural systems as a guide. By studying and manipulating the inner workings of ecological systems for the gardeners’ benefit, resilient gardens, specifically forest gardens, can be created.

Forest Gardens Defined

Forest gardens imitate woodlands found in the natural world and modify them slightly to meet human needs. *Edible Forest Gardens: Ecological Vision and Theory for Temperate Climate Permaculture* defines a forest garden as “a consciously designed community of mutually beneficial plants and animals intended for human [use]” (1). If well-designed, these gardens can potentially offer numerous resources including but not limited to food, fuel, and building materials without requiring heavy maintenance. Rather than demanding human labor, the gardens largely support themselves through the teamwork of both living (biotic) and nonliving (abiotic) factors. The sum of all relationships between these biotic and abiotic factors create ecosystems; thus, a forest garden is essentially a mimicked ecosystem.

Ecology Defined

The study of ecosystems on a large scale is referred to as ecology (Bidlack, Jansky, and Stern 479). In order to create successful forest gardens, several ecological principles must be considered. Natural cycles including the water, nitrogen, and phosphorus cycles dictate how plant resources will travel through a forest garden. As various groups of living organisms cross paths, they will form combinations of positive and negative relationships which range from affecting species beneficially to detrimentally. Some of the most important interactions will involve energy flow through food chains and webs. Moreover, succession, “changes in plant community composition and structure over time”, will determine the structure of a mature forest garden and, therefore, the initial placing of various plants (Jacke 239). Each of these ecological principles operates slightly differently depending on an area’s conditions; however, addressing the ecological principles of every possible forest garden location in this paper is not feasible. For that reason, the roles of the ecological principles will be discussed in only the context of the temperate broadleaf forest, the “[environment] located throughout midlatitude regions where there is sufficient moisture to support the growth of large, broadleaf deciduous trees” (Reece et al. G-34).

The Hydrologic Cycle

Aside from sunlight, the first plant need that typically comes to a gardener’s mind is water. All of Earth’s living organisms require this valuable compound, and all must rely on the hydrologic or water cycle, “[the] constant movement of water from the Earth into the atmosphere and back again”, to obtain it (Raven, Evert, and Eichhorn 705). During the water cycle, evaporation (“the process by which a liquid changes to a gas”) and transpiration (“the evaporative loss of water from a plant”) carry water as vapor into the atmosphere (Reece et al. G-13, G-35). The accumulating water vapor will eventually become too dense for the atmosphere to hold, and precipitation will cause the water to fall from the atmosphere. This rain will either move through "the soil and its layers by gravity and capillary forces" (percolation) and become available for plants to utilize or runoff into a larger body of water ("Description of the Hydrologic Cycle"). If the water is absorbed up by a plant, it will ultimately exit as water vapor through the leaves of that plant by a process called transpiration, but if it ends up in a larger body of water, it will eventually evaporate. Both outcomes result in the repetition of the water cycle (Raven, Evert, and Eichhorn 705).

In the forest garden, the goal is to maximize percolation and minimize runoff and evaporation so that plants have an amble supply of water available to them. A diverse combination of water-conservation techniques accomplishes this. Swales, "shallow trench[es] laid out dead level along the land's contours...", slow runoff and allow it to sink into the ground where it can be stored (Hemenway 287). Utilizing both living and non-living mulches as well as dense plantings can reduce evaporation, control erosion, and offer soil stabilization. In addition, native plants adapted to the site's water conditions and soil high in organic content effectively conserve water (98). Incorporating a blend of water-conservation practices saves the gardener from the fatal mistake of putting all their eggs in one basket; if one method fails, several more are present to serve as backup.

Nutrient Cycles

In addition to water, plants also require nutrients for optimal growth and development, and, like water, many of these nutrients cycle through the environment. This paper will examine two of the many nutrient cycles, the nitrogen cycle followed by the phosphorus cycle.

Although about 78% of Earth's atmosphere contains nitrogen, plants cannot readily use this form of nitrogen. Plants must count on processes within the nitrogen cycle to convert atmospheric nitrogen to nitrogen compounds they can use such as ammonium and nitrate. These processes include ammonification, nitrogen fixation, nitrification, and assimilation (Raven, Evert, and Eichhorn 692). Ammonification occurs as decomposing organic matter releases ammonium. Nitrogen fixation was formerly mentioned in clover's ability to form symbiotic relationships with bacteria, which convert or 'fix' nitrogen into a form plants can absorb. According to *Campbell Biology*:

> One of the more important bacteria involved in [nitrogen] fixation is the genus *Rhizobium*, which forms intimate associations with the roots of legumes (such as peas, soybeans, alfalfa, and peanuts) and markedly alters their root structure... Along a legume's roots are swellings called nodules, composed of plant cells that have been "infected" by *Rhizobium* bacteria. (794)

Another means by which plants can obtain nitrogen is through nitrification. Nitrification is similar to nitrogen fixation in that bacteria fix the nitrogen, but unlike bacteria in nitrogen fixation which live in root nodules, bacteria in nitrification are free-living soil bacteria (Raven, Evert, and Eichhorn 707). In order for a plant to finally use the nitrogen obtained from ammonification, nitrogen fixation, or nitrification, assimilation must take place. By turning "inorganic nitrogen (nitrates and ammonia) into organic compounds", assimilation allows plants to metabolize the nitrogen they absorbed from ammonification, nitrogen fixation, or nitrification (Raven, Evert, and Eichhorn 699). At last, the plants have taken up their share of nitrogen, and the nitrogen can now begin its journey throughout the cycle again.

Whereas the majority of nitrogen exists in the atmosphere, the majority of phosphorus exists within the Earth's crust. As phosphoric rocks weather and erode, microscopic particles of phosphorus become available for plants to absorb. When organisms like plants or animals that have consumed phosphorus die, decomposers break the phosphorus within these organisms back down returning it to the soil where it can potentially be utilized by a plant a second time. Phosphorus can also leech out of soil to a larger body of water such as a lake or ocean. Here, the phosphorus and other sediment particles will settle to the water's bottom and become rock from pressure repeating the cycle once more. Although phosphorus readily exists in the soil, its scant and fairly immobile nature makes it difficult for plants to obtain. While bacteria play an important role in helping plants obtain nitrogen, mutualistic associations between fungi and roots help plants obtain phosphorus. These mutualistic associations are referred to as mycorrhizas (Raven, Evert, and Eichhorn 316). Two types of mycorrhizas exist, endomycorrhizas and ectomycorrhizas. In endomycorrhizal associations, the fungus penetrates the host cells. In ectomycorrhizal associations, the fungus "forms a sheath, or mantle, that surrounds the roots and also a network (the Hartig net) that grows around the [host] cells" (316). The presence of mycorrhizas increases the surface area of a plant's roots and, hence, allows plants to extend great distances in order to better acquire phosphorus.

Now that an understanding of the nitrogen and phosphorus cycles has been gained, a discussion of someways to embrace these nutrient cycles in the forest garden can take place. To imitate ammonification in the forest garden, leaf and other organic matter can be left on the ground rather than raked away. Allowing matter to decompose or compost in place will not only feed the forest but also create less work for the gardener. Because "the most efficient nitrogen-fixing bacteria are those that form symbiotic relationships with plants", species such as clover and legumes should be utilized in a forest garden to replenish the soil with nitrogen (Raven, Evert, and Eichhorn 707). Encouraging mutualistic associations of mycorrhizas to form can also help plants get the minerals they need for optimal health. As demonstrated, forest gardens can generate self-renewing soil fertility if nutrient cycles are welcomed by the gardener**.**

Biotic Interactions and the Importance of Biodiversity

The significance of biotic interactions, interactions between living organisms, was already illustrated in the previous section. To clarify, mycorrhizas assist in acquiring crucial nutrients for plants. In this mutualistic relationship, both organisms benefit: the plant more easily gets its nutrients while the fungi "receives... plant carbohydrates and vitamins essential for its [own] growth" (312). Additional combinations of positive and negative relationships include predation, parasitism, and competition among others. In predacious and parasitic interactions, one organisms benefits while the other suffers. If organisms experience competition, both organisms are harmed (Reece et al. 1215). In the following paragraphs, creating these types of biotic interactions through biodiversity ("the variety of organisms present... as well as the diversity of habitats and ecosystems") will be examined (Hemenway 286).

Because mutualism results in the most positive outcome, it is in the forest garden's best interest to maximize this type of interaction. When it comes to examples of mutualistic interactions, mycorrhizas are just the tip of the iceberg, but the, perhaps, most important mutualistic interaction is that between pollinator, the species who pollinates, and pollenizer, the plant species being pollinated. Without pollination, "the transfer of pollen from an anther [the 'male' part of the flower] to a stigma [the 'female' part of the flower]", fruits seen in a typical grocery store such as apples, strawberries, and tomatoes would not exist (Bidlack, Jansky, and Stern 600). Furthermore, without fruit formation, hundreds of thousands of plants could not reproduce. Pollination provides food for people and wildlife and also enables the pollenizer to give rise to another generation. To guarantee pollination in the forest garden, the designer should incorporate a wide variety of pollenizers for a wide variety of pollinators. Different pollinators, including insects, birds, and mammals, pollinate different species. Flower color, shape, and odor as well as nectar and pollen levels attract different species ("Simple Truth Brochure"). Not only will incorporating a diverse array of plants promise pollination, but it will also protect plants from pests which brings us to our next series of biotic interactions.

Pests can be detrimental to a forest garden or any ecosystem for that matter if left unchecked; unbalance often wrecks havoc. Various living creatures can help maintain ecosystem balance by eating opportunistic organisms, species who have outstepped their boundaries and are too high in numbers. Types of feeding relationships include predation and parasitism. Before diving into these relationships, how food energy is transferred throughout an ecosystem must be investigated. Light energy originates from the sun and is then transformed by producers into chemical energy through a process called photosynthesis (Bidlack, Jansky, and Stern 600). Consumers who cannot create their own energy must obtain their energy from these producers. To do so, primary consumers will eat the producers, secondary consumers will feed on these primary consumers, and tertiary consumers will devour the secondary consumers. The cycle ends with decomposers who provide minerals and nutrients for the producers (Reece et al. 1202). Much of the time, this flow of energy is shown through food chains and webs. Food chains are linear flows of energy often in the form of a pyramid. The pyramid illustrates the amount of energy generated by producers and available to primary, secondary, and tertiary consumers. Because "[energy] escapes in the form of heat... from one level to another[,]... the final consumer gains only a tiny fraction of the energy originally captured by the producer at the [base of the pyramid]" (Bidlack, Jansky, and Stern 500). Food webs resemble a net of many interlocking food chains. Both food chains and webs demonstrate how energy travels through an environment. Now that the transformation of food energy throughout ecosystems has been examined, the types of feeding relationships noted previously, predation and parasitism, can be discussed.

Predators and parasites defend plants in the forest garden by snacking on uncontrolled populations of pests. Ladybugs eating aphids finely portray the first feeding interaction, predation. Aphids, “small, soft-bodied insects with long slender mouthparts... [used] to pierce stems, leaves, and other tender plant parts and suck out fluids”, damage crops tremendously (Flint). Fortunately, ecology has a solution: the natural predator of the aphid, the ladybug. In this example, the plant represents the producer, the aphid stands for the primary consumer, and the ladybug symbolizes the secondary consumer. Ladybugs and other predators like spiders will ensure that no pest population ever gets too out of control. The next feeding interaction, parasitism, can be exemplified by the parasitic braconid wasp and cabbageworm caterpillar. The adult wasp lays its eggs inside its host, the caterpillar, and the hatchings will emerge within the cabbageworm’s body and eat it, literally, to death (Hemenway 153). Just as biodiversity helped encourage the mutualistic interaction of pollination, biodiversity also promotes beneficial predacious and parasitic interactions. The friendly ladybug and parasitic braconid wasp introduced can only stay in a forest garden if there is habitat for them. A mixture of numerous plant species provides this necessary habitat allowing the natural predators to do their jobs successfully (26).

The final biotic interaction, competition, results in the worst outcome and should, therefore, be minimized in the forest garden. Competition takes place when “...two species or individuals living near each other need the same resource, and that resource is scarce...” (Jacke 132). Most of the time, competition takes place between two members of the same species because members of the same species require the same resources. These intraspecific relationships (relationships between members of the same species) contrast with the interspecific relationships (relationships between members of different species) explored earlier in mutualism, predation, and parasitism (The Fuse School). Once again, biodiversity comes in to the rescue. An assortment of vegetation works nicely because "...plants [that] have different leaf forms, light requirements, and rooting depths" do not compete for resources (Hemenway 176).

As illustrated above, an awareness of the importance of biodiversity in creating biotic interactions ensures pollination, protects the forest garden from pests, and reduces competition between plants for resources. In order to ensure these interactions continue to exist as a forest garden establishes itself, the gardener must plan accordingly at the beginning. Succession prepares the individual for the mature forest garden.

Succession

The final ecological principle, succession, causes changes in soil moisture and fertility, sunlight levels, and biotic interactions to take place (Jacke 245). Consequently, careful research and planning accounting for succession must take place in the primary design of a forest garden. Classically defined, succession is "an orderly progression of changes in the composition of a community from the initial development of vegetation to the establishment of a climax community" (Bidlack, Jansky, and Stern 603). One must realize, this definition is flawed in that it over-simplifies "the complex reality of plant community change over time" ("About Forest Gardening"). Only very rarely will an ecosystem ever truly reach the climax community phase, "the final stage in a successional series" (Raven, Evert, and Eichhorn G-5). Regardless, the basic principles of this classic idea of succession stand true for forest garden design purposes and will, therefore, be applied (Jacke 287).

Classical succession can be further subdivided into primary and secondary succession. Primary succession occurs when a community must colonize an area where no soil was previously present (Bidlack, Jansky, and Stern 489). For instance, when two tectonic plates collide with each other and an island forms, soil does not automatically exist on the island. The soil must form gradually from the weathering of rocks and eventually the decomposition of the plants and other organisms that populate the area. In addition to the formation of new islands, retreating glaciers, landslides, and lava flows are also examples of primary succession. In contrast to primary succession, secondary succession occurs when the soil remains in tact (492). Forest fires demonstrate secondary succession. Forest fires wipe out all the large species of plants exposing the soil to sunlight. Pioneer species who thrive in direct sunlight quickly come in to protect the bare ground until larger bushes and trees establish themselves. As the larger species mature, the pioneer species will die back, and the forest will reach a stable point becoming a climax community until another major disturbance takes place. Forest gardening primarily pertains to this type of succession where existing soil and biomass ("living or dead tissues, chemicals, or other organics material produced by plants, animals, microbes, or other living things") are already prevalent (Jacke 349).

A gardener can obtain their desired forest garden through accelerated succession which entails planting all the species (both pioneer and trees) at once. Initially, a newly planted food forest will have a high percentage of full sun loving plants. As succession continues to alter sunlight availability for different layers of the forest garden over time and the canopy of the trees initially planted fills in, the understory of the forest garden will gradually progress from these full-sun plants to part-sun loving plants and eventually to shade-tolerant plants. Pioneer species referred to as buffer plants and nurse plants that serve to help chosen species flourish will die back as the canopy fills in over the years. When the forest garden finally reaches its ‘climax’, the gardener will get what was set out for in the first place: a mature canopy weighed down by heavy fruit.

The Design

With these presented ecological principles in mind, the following forest garden was designed specifically for Johnson County Community College’s (JCCC) Open Petal Farm (see figures A-D below). The design process consisted of a multitude of activities including developing a vision and mission for the project, assessing proposed project locations, consulting stakeholders of the project, creating a budget and implementation plan, presenting the project in order to obtain funds for needed materials and labor, and further refining the project until all wants and needs of those involved were satisfied. Future endeavors for the forest garden will include installation, maintenance, reevaluation, and further refinement. These design process activities and future efforts will be further discussed below.

JCCC’s forest garden project ignited with a mission to promote regenerative agricultural practices and strengthen the campus community by inviting people from across the disciplines to utilize the garden as an educational tool. Planned to largely maintain itself, the forest garden will consume minimal resources. Dense plantings, mulches, and swales will be utilized to conserve water while nutrient accumulators and nitrogen fixing plants will take the place of synthetic fertilizers and improve soil quality. Furthermore, the perennial nature of the forest will promote soil conservation and carbon sequestration as well as provide wildlife habitat. All of these diverse factors will contribute to a farm more resilient to severe weather, disease, and pests in the long run.

The forest garden will also promote community engagement by welcoming different departments on campus to utilize the forest garden as an educational medium. The forest garden will not only enhance the sustainable agriculture program by introducing students to agroecology, the science of integrated, sustainable food-system design based on natural systems, but also improve courses in biology, horticulture, environmental science, art, and anthropology among others. Students and their instructors will be invited to visit the forest garden to apply classroom material and theory. This opportunity in experiential education will allow students' knowledge to be taken to a whole new level. Students can watch plants transform from seed to fruit. Students can touch the textures of the farm's variety of crops. They can hear the crunch as they bite into nuts, taste the sweet juice as they snack on berries, and smell the fresh compost fertilizing their own crops. The forest garden will give students the opportunity to engage their five senses and open their eyes to the incredible world around them.

After the mission and vision of the project was identified, assessment of the land began. Open Petal Farm lies in a temperate climate where Missouri's deciduous forests meet Kansas's grasslands and prairies. Aerial photos of the land and walks about the area revealed that the initial vegetation consisted of turf grass and two mature mulberry trees while the land sloped towards the east. Incoming energies such as road noise, neighbors, students, faculty, and staff at JCCC, sunlight, storm runoff, and wind among others entered the site from various directions and were taken into account to create a design appropriate for the conditions. Soil samples were gathered to determine the health of the soil, and measurements of the square footage of the land were taken. Some of the most valuable information about the land was obtained from interviewing those who work closely with the farm, such as the campus farm manager, which ties closely to the next point, assessment of the people.

Assessment of the people is, perhaps, even more important than the land's assessment because, without support from people, a project cannot succeed. For this reason, support was sought out from the Student Sustainability Committee (SSC), a group of JCCC students charged with allocating the Sustainability Initiatives Fund for the advancement towards a more sustainable campus. After presenting a preliminary design to the SSC and receiving feedback, a refined design, budget, and implementation plan were later presented. Following this second proposal, the SSC agreed to fund trees, shrubs, and other various plants needed to establish the forest garden as well as supplies such as rakes to maintain the forest garden. The SSC also agreed to provide funding for seating and arbors to create an inviting environment for any future forest garden visitors.

With funding for the garden in place, the implementation plan will be able to begin in Fall 2015. Volunteers will provide the labor for the installation of the garden, and the Sustainable Agriculture program will be held responsible for the forest's maintenance in the future. In repayment for this maintenance, produce from the forest garden will supplement the harvest of JCCC's Campus Farm and be sold for the Sustainable Agriculture program's benefit. Over the course of the years, students with the Sustainable Agriculture program will have the opportunity to reevaluate the forest garden and further refine the garden as they see fit. Overall, this experience will provide students with a strong sense of empowerment, gained confidence, and self-worth demonstrating the endless possibilities of sustainable agriculture.

A

B

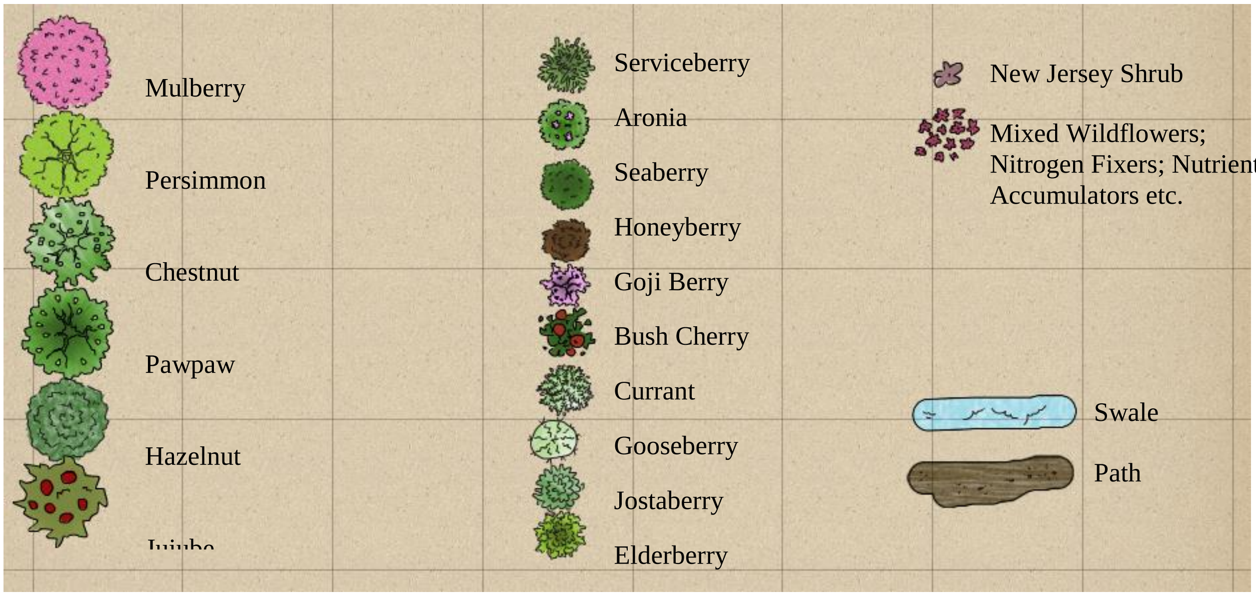
FIGURES

A. An arial view of JCCC for whom the forest garden was designed. The star represents where the project will be implemented.

B. A closer view of JCCC's Open Petal Farm.

C. The design key to plants and structures.

D. The illustrated design. Mulberries (the pink trees) were already present on the site and incorporated into the design.



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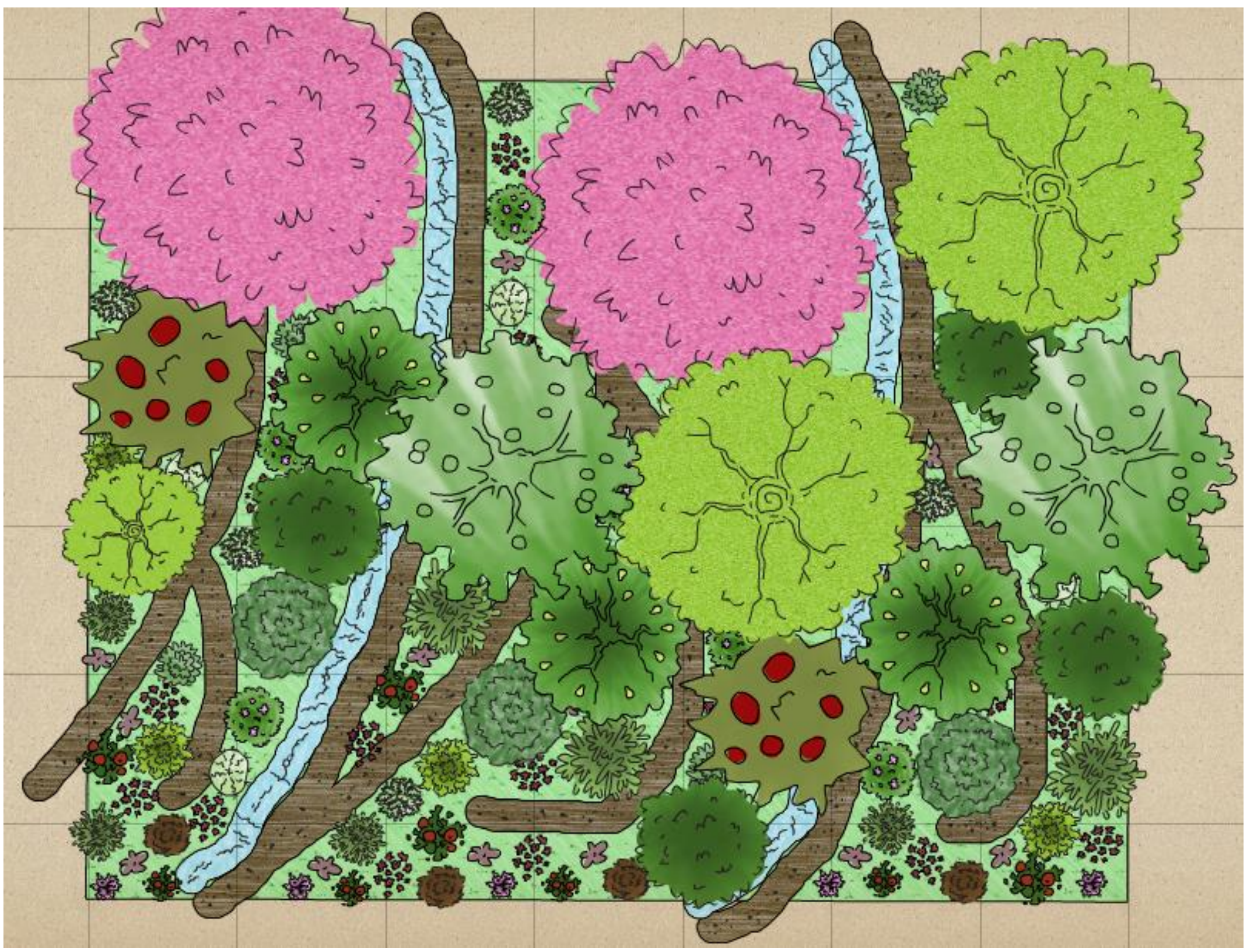

D

1 square = 15 feet

Conclusion

By studying and manipulating the inner workings of ecological systems for the gardeners' benefit, the past unsustainable gardening methods presented earlier in this paper can progress into more modern gardening practices that meet the needs of both present and future generations. Nature provides everything a resilient forest garden needs to thrive. Water and nutrients cycle freely throughout the mimicked ecosystem and support the survival of countless species in the forest garden. Interactions between living organisms created from biodiversity pollinate flowers, offer plants protection from pests, and keep species from fighting over each other for resources. Ultimately, the forest garden evolves through succession to provide a sustainable, diverse, and ecologically sound environment for plants, animals, insects, and humans. So long as the gardener invites these ecological principles into their forest gardens with open arms, the natural world will always graciously offer its wisdom.

Works Cited

"About Forest Gardening." Edible Forest Gardens. Dave Jacke, n.d. Web. 19 May 2015.

Bidlack, James E., Shelley H. Jansky, and Kingsley R. Stern. Stern's Introductory Plant Biology. 12th ed. New York: McGraw-Hill, 2008. Print.

"Description of Hydrologic Cycle." *Nwrfc.noaa.gov*. The National Oceanic and Atmospheric Administration, n.d. Web. 22 May 2015.

Flint, M. L. "Aphids Management Guide." *UC Davis Integrated Pest Management*. University of California, n.d. Web. 19 May 2015.

Hemenway, Toby. *Gaia's Garden: A Guide to Home-Scale Permaculture*. 2nd ed. White River Junction, VT: Chelsea Green Pub., 2009. Print.

Jacke, Dave, and Eric Toensmeier. *Edible Forest Gardens: Ecological Vision and Theory for Temperate Climate Permaculture*. Vol. 1. White River Junction, VT: Chelsea Green Pub., 2005. Print.

"Lake Succession and Eutrophication." Government of New Brunswick. Government of New Brunswick, n.d. Web. 1 Dec. 2014.

Raven, Peter H., Ray F. Evert, and Susan E. Eichhorn. *Raven Biology of Plants*. 8th ed. New York: W.H. Freeman, 2013. Print.

Reece, Jane B., Lisa A. Urry, Michael L. Cain, Steven Alexander Wasserman, Peter V. Minorsky, Rob Jackson, and Neil A. Campbell. *Campbell Biology*. 9th ed. Boston: Pearson Benjamin Cummings, 2011. Print.

"Simple Truth Brochure." U.S. Forest Service, n.d. Web. 19 May 2015.

The Fuse School. "Interspecific and Intraspecific Interactions." Online video clip. *YouTube*. YouTube, 4 January 2013. Web. 19 May 2015.